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Apprenticeship and Industry Training

Millwright

Apprenticeship Course Outline

1605 (2005)

Alberta
Advanced Education
Apprenticeship and Industry Training

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Millwright

Table of Contents

Apprenticeship and Industry Training System 2
Apprenticeship and Industry Training Committee Structure 2
Local Apprenticeship Committees (Lac) 2
Provincial Apprenticeship Committees (Pac) 3
The Alberta Apprenticeship and Industry Training Board (Board) 3
Safety Education 3
Legal and Administrative Aspects of Safety 4
Technical Training Establishment 4
Procedures for Recommending Revisions to the Course Outline 5
Apprenticeship Route Toward Certification 6
Millwright Training Profile 7

Course Outline

First Period Technical Training 14
Second Period Technical Training 24
Third Period Technical Training 33
Fourth Period Technical Training 42

Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly-skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Millwright apprenticeship training is a journeyman who will be able:

- understand the principles of sound and safe trade practice.
- interpret drawings, plans, and be able to layout and develop projects according to specifications.
- use the tools of the trade in a safe and proper manner.
- relate to the work of other tradesmen employed in the industry either on construction or in maintenance.
- perform assigned tasks in accordance with quality and production standards required in industry.

Apprenticeship and Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Alberta Apprenticeship and Industry Training Board, with the support of Alberta Advanced Education, oversee the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Millwright PAC Members

Mr. G. Becker	Edmonton	Presiding Officer
Mr. G. Whalen.	Fort McMurray	Employer
Mr. K. Falconer	Edmonton	Employer
Mr. J. Hazeldine	Edmonton	Employer
Mr S. Fournier.	Calgary	Employee
Mr. D Harrish	Edmonton	Employee
Mr. C. Osmond	Fort McMurray	Employee
Mr. S. Cote	Hinton	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Advanced Education on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chairman, eight members representing trades and four members representing other industries. The trades and other industry members are equally represented by employer and employee representatives.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act and Regulations dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment and protective devices.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Workplace Health and Safety's Responsibilities:

Workplace Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Advanced Education, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by:

- Northern Alberta Institute of Technology
- Southern Alberta Institute of Technology
- Keyano College
- Northern Alberta Institute of Technology (Grande Prairie)

Procedures for Recommending
Revisions to the Course Outline

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Millwright Provincial Apprenticeship Committee.

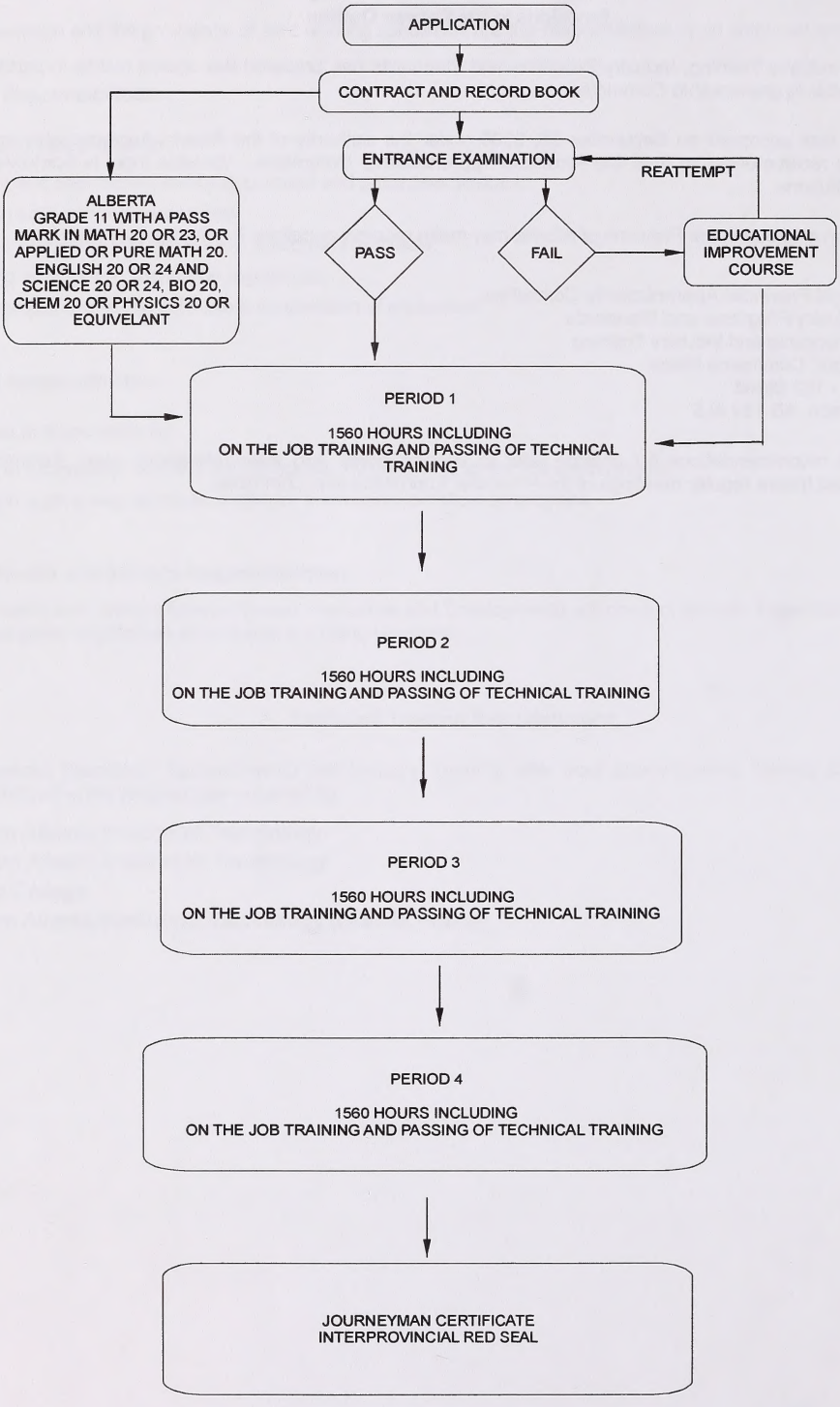
This course outline was approved on September 30, 2005 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institutions.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Millwright Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route toward Certification



Millwright Training Profile

FIRST PERIOD

(240 Hours)

SECTION ONE

SAFETY
160101 8 Hours

A	B	C
General Safety *160101a* 3 Hours	Fire Safety *160101b* 2 Hours	WHMIS *160101c* 1 Hour

D
Ladders and Scaffolds *160101d* 2 Hours

SECTION TWO

MEASURMENT AND LAYOUT
160102 15 Hours

A	B	C
Measurement Basics *160102a* 5 Hours	Measuring Tools *160102b* 2 Hours	Layout *160102c* 2 Hours

D
Precision Measuring Tools *160102d* 6 Hours

SECTION THREE

BENCHWORK
160103 8 Hours

A	B
Benchwork (Non-cutting Hand Tools) *160103a* 3 Hours	Benchwork (Hand Held Cutting Tools *160103b* 5 Hours

SECTION FOUR

THREADS AND FASTENERS
160104 9 Hours

A	B	C
Threaded Fasteners and Locking Devices *160104a* 3 Hours	Non-Threaded Fasteners and Locking Devices *160104b* 3 Hours	Installation and Removal of Fasteners *160104c* 3 Hours

SECTION FIVE

GRINDERS AND SAWS
160105 5 Hours

A	B
Grinders *160105a* 2 Hours	Power Saws *160105b* 3 Hours

SECTION SIX

MACHINING
160106 24 Hours

A	B	C
Drilling *160106a* 6 Hours	Milling *160106b* 3 Hours	Lathe Construction and Accessories *160106c* 6 Hours

D	E	F
Lathe Operations *160106d* 7 Hours	Tapers *160106e* 1 Hour	Machine Cutting Fluids *160106f* 1 Hour

SECTION SEVEN

METALLURGY
160107 5 Hours

A
Metallurgy *160107a* 5 Hours

SECTION EIGHT

MACHINE ALIGNMENT
160108 11 Hours

A	B
Grouting, Levelling, and Anchoring *160108a* 3 Hours	Rim and Face Shaft Alignment *160108b* 8 Hours

SECTION NINE

RIGGING
160109 14 Hours

A	B
Rigging Procedures *160109a* 10 Hours	Crane and Hoists *160109b* 4 Hours

SECTION TEN

TRADE MATH
32 Hours

A	B	C
Working With Numbers *160110a*	Fractions *160110b*	Decimals *160110c*
D	**E**	**F**
Measurement and Conversions *160110d*	Percentage, Ratio, Graphs and Tables *160110e*	Introduction to Triangles and Trigonometry *160110f*
G		
Math Formulas *160110g*		

SECTION ELEVEN

APPLIED PRINT READING
24 Hours

A	B	C
Introduction to Applied Print Reading: Sketching and Drawings *160111a*	Introduction to Applied Print Reading: Prints and Drawings *160111b*	Applied Print Reading: Pictorial Drawings *160111c*
D	**E**	**F**
Applied Print Reading: Sections *160111d*	Applied Print Reading: Limits, Fits, Tolerances *160111e*	Metal Identification and Structural Steel Shapes *160111f*

SECTION TWELVE

SHOP WORK
85 Hours

A	B	C
Measurement and Layout	Benchwork	Threads and Fasteners
D	**E**	**F**
Grinders and Saws	Machining	Metallurgy
G	**H**	
Machine Alignment	Rigging	

SECOND PERIOD

(240 Hours)

SECTION ONE

GASKETS
160201 6 Hours

A
Gaskets
160201a 6 Hours

SECTION TWO

BEARINGS AND SEALS
160202 22 Hours

A
Anti-Friction Bearing Classification and Identification
160202a 3 Hours

B
Anti-Friction Bearing Removal and Installation
160202b 8 Hours

C
Plain Bearings
160202c 5 Hours

D
Bearing Maintenance
160202d 4 Hours

E
Bearing Seals and Pillow Blocks
160202e 2 Hours

SECTION THREE

POWER TRANSMISSION
160203 44 Hours

A
Couplings
160203a 8 Hours

B
Clutches and Brakes
160203b 8 Hours

C
Shafting, Fits and Accessories
160203c 4 Hours

D
Power Transmission—Belts
160203d 6 Hours

E
Power Transmission—Chain
160203e 6 Hours

F
Gearing Fundamentals
160203f 5 Hours

G
Gear Installation and Maintenance
160203g 5 Hours

H
Variable Speed Power Transmission Devices
160203h 2 Hours

SECTION FOUR

ALIGNMENT
160204 8 Hours

A
Cross Dial Alignment
160204a 8 Hours

SECTION FIVE

RECIPROCATING COMPRESSORS
160205 24 Hours

A
Compressor Fundamentals
160205a 4 Hours

B
Repair of Compressor Stationary Components
160205b 4 Hours

C
Repair of Compressor Moving Components
160205c 4 Hours

D
Repair of Compressor Valves and Gas Sealing
160205d 4 Hours

E
Compressor Servicing
160205e 4 Hours

F
Compressor Overhaul and Start-up Procedures
160205f 4 Hours

SECTION SIX

CUTTING AND WELDING
160206 8 Hours

A
Oxyacetylene Equipment and Procedures
160206a 5 Hours

B
Electrical Arc Welding
160206b 3 Hours

SECTION SEVEN

LUBRICATION
160207 8 Hours

A
Lubrication
160207a 8 Hours

SECTION EIGHT

TRADE MATH
24 Hours

A	B	C
Area, Volume and Capacities *160208a*	Transmission of Force and Motion *160208b*	Gas Laws and Coefficient of Linear Expansion *160208c*

D
Alignment Calculations 160208d

SECTION NINE

APPLIED PRINT READING
24 Hours

A	B	C
Applied Print Reading: Auxiliary Views and Assembly Drawings *160209a*	Applied Print Reading: Single Line Drawings *160209b*	Castings *160209c*

D	E	F
Basic Joints and Weld Types *160209d*	Welding Symbols *160209e*	Applied Print Reading: mechanical Components *160209f*

SECTION TEN

SHOP WORK
72 Hours

A	B	C
Gaskets	Bearings and Seals	Power Transmission

D	E	F
Alignment	Reciprocating Compressors	Cutting and Welding

G
Lubrication

THIRD PERIOD
(240 Hours)

SECTION ONE

HYDRAULIC AND PNEUMATICS
160301 44 Hours

A	B	C
Introduction to Hydraulics *160301a* 9 Hours	Hydraulic Valves *160301b* 5 Hours	Hydraulic Pumps and Actuators *160301c* 6 Hours

D	E	F
Accessories, Fluids and Seals *160301d* 6 Hours	Troubleshooting and Maintenance *160301e* 6 Hours	Pipe *160301f* 4 Hours

G	H
Valves *160301g* 2 Hours	Pneumatic Systems *160301h* 6 Hours

SECTION TWO

INDUSTRIAL REFRIGERATION AND HEAT EXCHANGERS
160302 14 Hours

A	B	C
Industrial Refrigeration *160302a* 6 Hours	Heat Exchangers *160302b* 6 Hours	Insulation *160302c* 2 Hours

SECTION THREE

EXPLOSIVE AND AIR TOOLS
160303 5 Hours

A	B
Air Tools *160303a* 2 Hours	Explosive Actuated Tools *160303b* 3 Hours

SECTION FOUR

COMPRESSORS AND FANS
160304 26 Hours

A	B	C
Screw Compressors and Lobe Blowers *160304a* 8 Hours	Vane and Liquid Compressors *160304b* 8 Hours	Dynamic Compressors *160304c* 7 Hours

D
Fans *160304d* 3 Hours

SECTION FIVE

DRYERS
160305 8 Hours

A
Gas and Air Dryers *160305a* 8 Hours

SECTION SIX

ALIGNMENT AND SURVEY
160306 14 Hours

A	B	C
Laser Shaft Alignment *160306a* 4 Hours	Optical Levelling and Alignment *160306b* 6 Hours	Machine Levelling *160306c* 4 Hours

SECTION SEVEN

COMPUTER IN INDUSTRY
160307 17 Hours

A	B
Information Gathering, Computers and Catalogues *160307a* 8 Hours	Managed Maintenance Systems *160307b* 9 Hours

SECTION EIGHT

NON-DESTRUCTIVE TESTING
160308 4 Hours

A
Non-Destructive Testing *160308a* 4 Hours

SECTION NINE

ELECTRICAL
160309 12 Hours

A	B
Electrical Principles *160309a* 6 Hours	Practical Electricity *160309b* 6 Hours

SECTION TEN

TRADE MATH
16 Hours

A	B
Hydraulic Calculations *106310a*	Electrical Calculations *1602310b*

SECTION ELEVEN

PRINT READING — 16 Hours

A
Hydraulic and Pneumatic Systems
160311a

SECTION TWELVE

SHOP WORK — 64 Hours

A
Hydraulics and Pneumatics

B
Industrial Refrigeration and Heat Exchangers

C
Explosive and Air Tools

D
Compressors and Fans

E
Dryers

F
Alignment and Survey

G
Computer in Industry

H
Non-Destructive Testing

I
Electrical

FOURTH PERIOD
(240 Hours)

SECTION ONE

PRIME MOVERS
160401 — 49 Hours

A
Stationary Independent Engine Fundamentals
160401a — 3 Hours

B
Engine Component Identification and Repair
160401b — 10 Hours

C
Engine Systems and Servicing
160401c — 9 Hours

D
Engine Installation and Start-up
160401d — 2 Hours

E
Steam Turbines
160401e — 12 Hours

F
Gas Turbines
160401f — 6 Hours

G
Governors
160401g — 7 Hours

SECTION TWO

VIBRATION
160402 — 20 Hours

A
Vibration Analysis
160402a — 8 Hours

B
Balancing
160402b — 4 Hours

C
Electronic Controls and Troubleshooting
160402c — 4 Hours

D
Industrial Controls: Schematics, Ladder Diagrams and Logic Control
160402d — 4 Hours

SECTION THREE

MACHINE LEVELLING
160403 — 7 Hours

A
Advanced Alignment
160403a — 7 Hours

SECTION FOUR

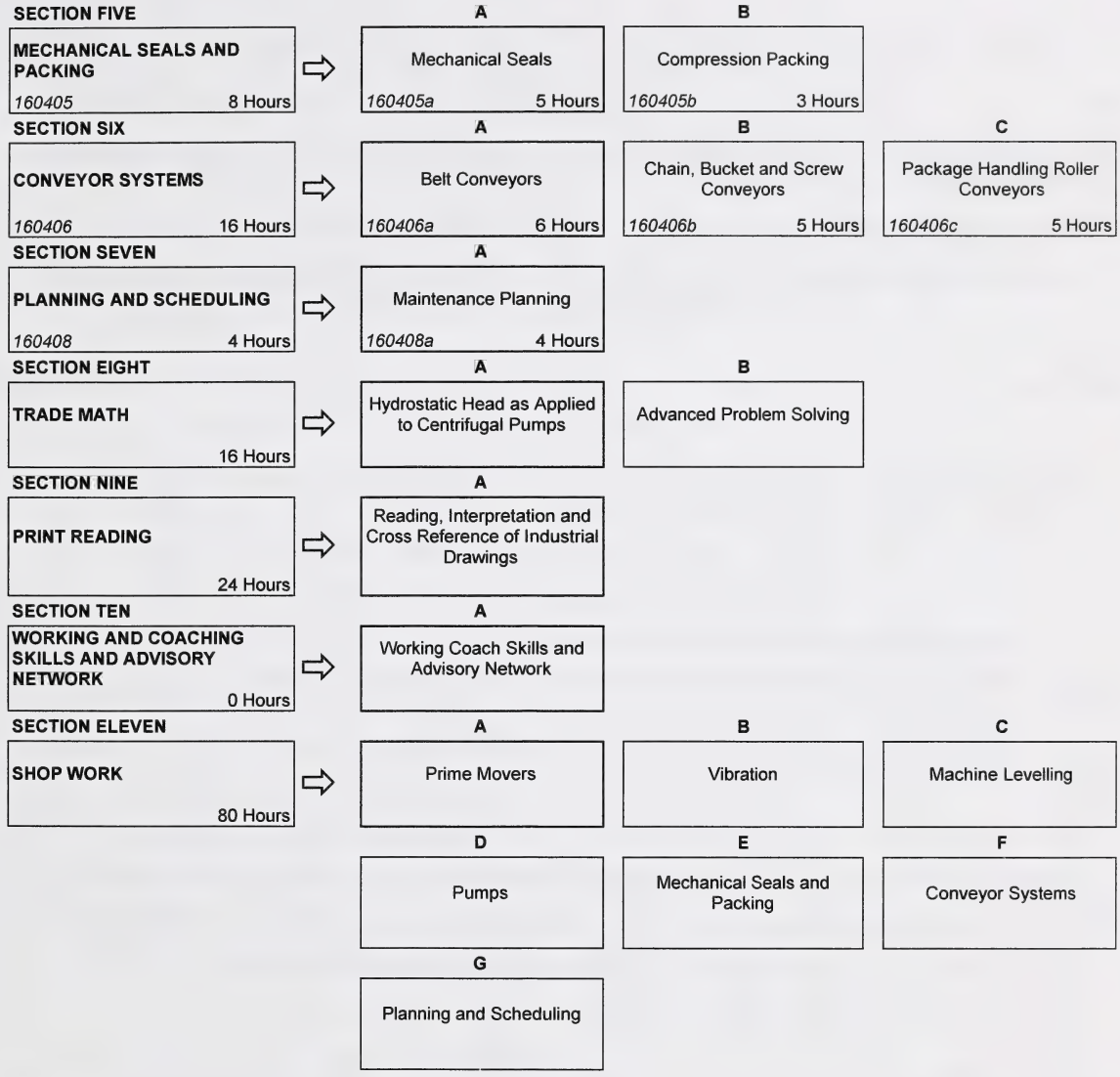
PUMPS
160404 — 16 Hours

A
Dynamic Pump Selection
160404a — 4 Hours

B
Dynamic Pump Construction
160404b — 6 Hours

C
Positive Displacement Pumps
160404c — 4 Hours

D
Pump Operation and Repair
160404d — 2 Hours



NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice Advanced Education, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training

FIRST PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE

Due to the nature of the work of the Millwright trade it is imperative that safety, WHMIS and environmental concerns be taught on a continuous basis throughout the entirety of this course.

It is industry's intent that the practical portion of the program enhances the theory section of the course outline.

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE ..... SAFETY ..... 8 HOURS

A. General Safety (160101a) ..... 3 Hours

Outcome: Describe safe work practices and environmental protection.

1. Explain responsibilities of the employee, employer, and government.
2. Describe General Safeties and Accident Prevention.
3. Describe Environmental Protections and Material Handling.
4. Describe Personal Protective Equipment and Practices Used In Industrial Applications.
5. Explain Breathing Air Safeguards.
6. Define Industrial Safety Applications.

B. Fire Safety (160101b) ..... 2 Hours

Outcome: Identify and describe fire classes, extinguishers, prevention, detection, cleanup and restoration.

1. Describe the classes of fires and the appropriate fire extinguishers suitable to fight each of these fires.
2. Describe procedures and equipment related to preventing, detecting and warning of fires.
3. Describe fire cleanup and restoration procedures.

C. WHMIS (160101c) ..... 1 Hour

Outcome: Apply the requirements of WHMIS to the work site.

1. Describe the three key elements of WHMIS.
2. Identify WHMIS hazard symbols.
3. Interpret the Material Safety Data Sheet (MSDS).

D. Ladders and Scaffolds (160101d) ..... 2 Hours

Outcome: Identify and describe types and applications of ladders and scaffolding.

1. Describe the use of various types and applications of ladders.
2. Describe the use of various types and applications of scaffolds.

SECTION TWO ..... MEASURING AND LAYOUT ..... 15 HOURS

A. Measurement Basics (160102a) ..... 5 Hours

Outcome: Define the limits, tolerances, allowances and fits of various machine parts in both imperial and metric SI (International System of Units) terms.

1. Convert measurements between fractions and decimals.
2. Define limits, tolerances, allowances and fits in imperial terms.
3. Define limits, tolerances, allowances and fits in metric SI terms.

B. Measuring Tools (160102b) ..... 2 Hours

Outcome: Describe the use of measuring tools for the millwright trade.

1. Assess the effect of temperature change on the dimensions of objects being measured, with regard to various materials.
2. Identify basic measuring tools used in the millwright trade.
3. Describe comparison measurement.
4. Describe the use of squares and protractors.

C. Layout (160102c) ..... 2 Hours

Outcome: Describe layout procedures and identify layout tools.

1. Identify the tools used for layout procedures.
2. Explain layout purpose and procedures.

D. Precision Measuring Tools (160102d) ..... 6 Hours

Outcome: Describe the use of precision measuring tools.

1. Describe vernier instruments and their uses.
2. Describe the types of micrometers and their uses.
3. Describe comparison measurement using dial indicators.

SECTION THREE ..... BENCHWORK ..... 8 HOURS

A. Benchwork (Non-cutting tools) (160103a) ..... 3 Hours

Outcome: Identify and describe use of non-cutting hand tools.

1. Identify common tools used for performing non-cutting bench-work procedures.
2. Describe hydraulic jacks, pullers and presses.
3. Describe methods used in the workshop for cleaning machine parts (non-cutting).

B. Benchwork (Hand Held Cutting Tools) (160103b) ..... 5 Hours

Outcome: Describe the correct use and maintenance of cutting type hand tools.

1. Describe the use and maintenance of common hand-held cutting tools used in benchwork.
2. Describe the use of abrasive cloths and the process of hand lapping.
3. Describe the care and use of taps and dies.
4. Describe the care and use of hand reamers and broaches.

SECTION FOUR ..... THREADS AND FASTENERS ..... 9 HOURS

A. Threaded Fasteners and Locking Devices (160104a) ..... 3 Hours

Outcome: Identify metric and imperial threaded fasteners and describe typical applications.

1. List reasons for and describe personal safety equipment required when working with fasteners and anchors.
2. Identify and describe various threaded fasteners and their applications.
3. Identify metric and imperial thread classes and fits.
4. Identify and list the types and purposes of threads and thread forms.
5. Calculate and list reasons for calculating necessary thread dimensions.
6. Describe thread measuring tools, methods and procedures.
7. Describe thread manufacturing methods.

B. Non-Threaded Fasteners and Locking Devices (160104b) ..... 3 Hours

Outcome: Explain non-threaded fasteners and locking devices.

1. Identify the types and purposes of non-threaded fasteners.
2. Explain the types and applications of locking devices.

C. Installation and Removal of Fasteners (160104c) ..... 3 Hours

Outcome: Explain the installation and removal of fasteners.

1. Describe methods of removing broken fasteners and thread reconditioning.
2. Explain the theory of tensioning.
3. Describe methods of tensioning.

SECTION FIVE ..... GRINDERS AND SAWS ..... 5 HOURS

A. Grinders (160105a) ..... 2 Hours

Outcome: Describe the safe use and maintenance of grinders.

1. Explain the safety rules pertaining to offhand grinder use.
2. Explain the operation, types, parts and application of offhand grinders.
3. Describe grinding wheel selection, installation and maintenance procedures.

B. Power Saws (160105b)..... 3 Hours

Outcome: Describe metal and wood cutting saws used in industry.

1. Describe power hacksaws, their operation, application and attachments.
2. Describe band saws, their operation, application and attachments.
3. Describe abrasive cut-off saws, their operation, application and attachments.
4. Describe chainsaws, their operation, application and attachments.

SECTION SIX .....MACHINING.....24 HOURS

A. Drilling (160106a)..... 6 Hours

Outcome: Describe the procedures for operating drilling machines.

1. Describe types, parts and applications of drilling machines.
2. Describe holding devices for machines and tools.
3. Describe drilling tools and their applications.
4. Explain the operation, speeds and feeds of drilling machines.
5. Describe care and maintenance of drilling tools.
6. Describe care and maintenance of drilling machines.

B. Milling (160106b) ..... 3 Hours

Outcome: Describe the safe use and maintenance of milling machines.

1. Describe types, parts and applications of milling machines.
2. Describe milling tools and accessories and their applications.
3. Explain the operation, speeds and feeds of milling machines.
4. Describe maintenance of milling machines.

C. Lathe Construction and Accessories (160106c)..... 6 Hours

Outcome: Describe the sizing, parts, accessories and attachments of lathe types.

1. Describe lathe safety.
2. Describe the construction of lathes.
3. Describe work holding devices.
4. Describe lathe accessories.
5. Describe tool holding devices.

D. Lathe Operations (160106d) ..... 7 Hours

Outcome: Describe the safe use and maintenance of engine lathes.

1. Explain cutting and forming tools and sharpening procedures.
2. Describe lathe turning operations.
3. Describe lathe boring operations.
4. Describe lathe threading operations.
5. Describe lathe surface finishing operations.
6. Describe lathe maintenance.

E. Tapers (160106e) ..... 1 Hour

Outcome: Apply taper systems to machining operations.

1. Describe taper applications and installation of tapers.
2. Describe manufacture and repairs of tapers.

F. Machine Cutting Fluids (160106f) ..... 1 Hour

Outcome: Apply lubricants to reduce friction and increase efficiency.

1. Describe functions of cutting fluids.
2. Describe applications for cutting fluids.

SECTION SEVEN .....METALLURGY .....5 HOURS

A. Metallurgy (160107a) ..... 5 Hours

Outcome: Select the correct type of metal for an application.

1. Explain the physical properties of metals.
2. Describe metal manufacturing processes.
3. Describe types and classifications of metals.
4. Explain the heat treatment of metals.
5. Explain tensile and hardness testing of metals.

SECTION EIGHT .....MACHINE ALIGNMENT .....11 HOURS

A. Grouting, Levelling, and Anchoring (160108a) ..... 3 Hours

Outcome: Describe machine levelling and grouting procedures.

1. Describe levelling tools, equipment and procedures
2. Explain the types, purposes and methods of grouting.

B. Rim and Face Shaft Alignment (160108b) ..... 8 Hours

Outcome: Align two machine shafts using the rim and face method.

1. List the reasons for aligning machine shafts.
2. Describe pre-alignment procedures
3. Describe machine shaft alignment procedures with regards to the rim and face method of shaft alignment.
4. Determine the alignment corrections required to align two machine shafts in the vertical plane, using the rim and face formula method.
5. Determine the alignment corrections required to align two machine shafts in the horizontal plane, using the rim and face formula method.

SECTION NINE..... RIGGING .....14 HOURS

A. Rigging Procedures (160109a)..... 10 Hours

Outcome: Describe rigging and hoisting equipment and procedures.

1. Describe the construction of wire rope.
2. Describe the construction and use of steel and fibre slings.
3. Describe hoisting equipment hardware.
4. Describe construction and use of chain and chain slings.
5. Describe the construction of fibre rope and the purpose and use of knots.
6. Estimate the weight of various objects when given the size, shape and material.
7. Describe hand-rigging equipment.
8. Describe standard hand signals used for rigging and hoisting operations.
9. Describe hoisting and load moving procedures.

B. Cranes and Hoists (160109b) ..... 4 Hours

Outcome: Use cranes and hoists for lifting and moving objects.

1. Describe the types of mobile cranes.
2. Describe the set up and safety procedures for mobile cranes.
3. Describe the electric overhead traveling cranes.
4. Describe electric overhead traveling crane inspection procedures.

SECTION TEN ..... TRADE MATH ..... 32 HOURS

A. Working with Numbers (160110a)

Outcome: Perform mathematical operations with whole numbers.

1. Read whole numbers by using place values and perform rounding operations.
2. Perform addition and subtractions with whole numbers.
3. Perform multiplication and divisions with whole numbers.
4. Identify signed numbers and perform operations with such numbers.

B. Fractions (160110b)

Outcome: Solve problems involving fractions.

1. Identify key terms and concepts used when working with fractions.
2. Change fractions to common denominations.
3. Solve problems using fractions and mixed numbers.
4. Perform practical exercises using fractions and mixed numbers.

C. Decimals. (160110c)

Outcome: Perform calculations, conversions and solve practical problems with decimal numbers

1. Read and write decimal fractions and decimal numbers.
2. Round decimal numbers to specified place values.
3. Convert decimal numbers to decimal fractions.
4. Convert decimal inches to decimal numbers.
5. Add and subtract decimal numbers.
6. Multiply and divide decimal numbers.
7. Convert decimal numbers to common fractions with practical denominators.
8. Convert decimal feet to feet and inches and convert inches to feet.

D. Measurement and Conversions (160110d)

Outcome: Solve problems involving measurement and conversion using geometric formulas.

1. Identify the measuring systems for linear measurement, angular measurement, weight and capacity, and explain how to convert from Imperial to Metric (SI).
2. Identify key terms and concepts used in working with formulas.
3. Define perimeter and identify common formulas to calculate perimeter in Imperial and Metric (SI) systems.
4. Define area and identify common formulas to calculate area in Imperial and Metric (SI) systems.
5. Define volume and identify common formulas to calculate volume in Imperial and metric (SI) systems.
6. Define mass and identify common formulas to calculate mass in Imperial and Metric (SI) systems.
7. Define capacity and identify common formulas to calculate capacity in Imperial and Metric (SI) systems.
8. Define the parts of a circle and identify common formulas to calculate those parts of a circle in Imperial and Metric (SI) systems.

E. Percentage, Ratio, Graphs and Tables (160110e)

Outcome: Solve problems involving percentage and ratios.

1. Calculate ratio problems: express two quantities in the form of a ratio.
2. Calculate ratio problems: express two ratios on the form of a proportion.
3. Convert between fractions and percents.
4. Convert between decimals and percents.
5. Solve percent problems.
6. Read and interpret information on graphs and charts.

F. introduction to Triangles and Trigonometry (160110f)

Outcome: Solve problems involving special triangles and elementary trigonometry.

1. Identify key terms and concepts used in working with triangles and trigonometry.
2. Identify special triangles and solve problems using related formulas.
3. Identify Pythagorean theory and use it to solve problems.
4. Identify trigonometric formulas and solve problems using formulas.

G. Math Formulas (160110g)

Outcome: You will be able to recognize math symbols used in millwright trade calculations. You will also be able to select from a list, the correct formula for a specific problem solving application at your training level.

1. Locate math formulas to apply to specific trade calculations in the four periods of millwright training.

SECTION ELEVEN.....APPLIED PRINT READING.....24 HOURS

A. Introduction to Applied Print Reading: Sketching and Drawing (160111a)

Outcome: Identify and sketch components.

1. Identify the six planes of an orthographic projection and the key view.
2. Identify first and third angle projection and recognize the ISO symbol for each projection.
3. Describe the types of lines used on prints and their application.
4. Describe basic sketching equipment.
5. Use basic rules to apply text and dimensions to a component drawing.
6. Sketch and dimension simple objects in orthographic projection.

B. Introduction to Applied Print Reading: Prints and Drawings (160111b)

Outcome: Read drawings with different technical elements and correctly interpret the dimensions of those elements.

1. Describe the different methods of applying special dimensions to a technical element on a print.
2. State the methods used to express the amount of taper on a component drawing.
3. Calculate for missing dimensions on a drawing.
4. Read dimensions on prints in both metric and imperial systems or dual dimensioning.

C Applied Print Reading: Pictorial Drawings (160111c)

Outcome: Sketch isometric pictorial drawings.

1. Describe three typed of picture views.
2. Sketch isometric drawings on isometric lined paper.

D. Applied Print Reading: Sections (160111d)

Outcome: Recognize and name technical elements of break lines and sectional representation.

1. Define the terms cutting plane lines, break lines and symmetry and describe their application.
2. Describe the use of sectional views and name the types of components that are not sectioned on a drawing.
3. Draw symbolic section lines for seven types of material.

E. Applied Print Reading: Limits, Fits and Tolerances (160111e)

Outcome: Read, interpret and sketch machine shop drawings containing advanced terminology.

1. Calculate the limits and fits for the mating parts on working drawings.
2. Apply all dimensions and tolerances to a set of working drawings.
3. Interpret prints including all information generally provided on prints, shop drawings and sketches.

F. Metal Identification and Structural Steel Shapes (160111f)

Outcome: Use a variety of techniques to identify different types of metal and identify structural steel shapes and know how they are specified.

1. Identify metals by visual appearance, colour, relative weight, typical shape and texture.
2. Describe chip, spark, file hardness and flame tests.
3. Interpret information supplied on mill test reports.
4. Identify structural shapes and know how they are specified.

SECTION TWELVE .....SHOP WORK.....85 HOURS

A. Measurement and Layout

B. Benchwork

C. Threads and Fasteners

D. Grinders and Saws

E. Machining

F. Metallurgy

G. Machine Alignment

H. Rigging

SECOND PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE ..... GASKETS ..... 6 HOURS

A. Gaskets (160201a) ..... 6 Hours

Outcome: Describe the installation and maintenance of gaskets used in industrial machinery.

1. Describe the safety rules and precautions applicable to the installation, removal and replacement of gaskets.
2. Describe the types of gasket joints common in industry.
3. List the types and applications of various kinds of gasket material.
4. Describe joint disassembly, and gasket removal techniques.

SECTION TWO ..... BEARINGS AND SEALS ..... 22 HOURS

A. Anti-Friction Bearing Classification and Identification (160202a) ..... 3 Hours

Outcome: Select appropriate anti-friction bearings for specified applications.

1. Identify the type, parts and functions of common anti-friction bearings.
2. Describe the type, size and features of anti-friction bearings from the bearing code.

B. Anti-Friction Bearing Removal and Installation (160202b). ..... 8 Hours

Outcome: Describe the replacement of anti-friction bearings.

1. Describe the various procedures used to remove anti-friction bearings.
2. Determine the correct shaft and housing sizes required to provide the correct fit to the anti-friction bearing.
3. Describe the preparations required before mounting anti-friction bearings.
4. Describe the drive or press-on methods of mounting anti-friction bearings.
5. Describe the oil injection and hydraulic nut methods of mounting anti-friction bearings.
6. Describe the various hot mounting procedures used to install anti-friction bearings.
7. Describe the procedures for setting internal clearances in anti-friction bearings.

C. Plain Bearings (160202c) ..... 5 Hours

Outcome: Describe the application, installation and remanufacture of plain bearings.

1. Describe the construction, function and application of plain bearings.
2. Describe the characteristics of the common plain bearing materials.
3. Describe the installation of plain bearings.
4. Describe appropriate safety measures applicable to Babbitt pouring.
5. Describe Babbitt pouring and fitting procedures.

D. Bearing Maintenance (160202d) ..... 4 Hours

Outcome: Reduce the frequency of bearing failures.

1. Describe the symptoms of bearing failure.
2. Describe the causes of bearing failure.
3. Describe bearing inspection methods.
4. Describe bearing lubrication methods.
5. Describe bearing maintenance procedures.

E. Bearing Seals and Pillow Blocks (160202e) ..... 2 Hours

Outcome: Describe the characteristics and applications of bearing seals and pillow blocks.

1. Describe the various types and applications of bearing seals
2. Describe the various types and uses of pillow blocks

SECTION THREE ..... POWER TRANSMISSION ..... 44 HOURS

A. Couplings (160203a) ..... 8 Hours

Outcome: Describe the types, application, replacement and maintenance of couplings.

1. Describe types and characteristics of rigid couplings.
2. Describe types and characteristics of flexible couplings.
3. Describe types and characteristics of special purpose couplings.
4. Describe various coupling applications.
5. Describe coupling removal and installation procedures.
6. Describe coupling maintenance procedures.

B. Clutches and Brakes (160203b) ..... 8 Hours

Outcome: Describe the types, applications, replacement and maintenance of clutches and brakes.

1. Describe the types, principles of operation and applications of mechanical clutches.
2. Describe the types, principles of operation and applications of hydraulic clutches.
3. Describe the types, principles of operation and applications of electric clutches.
4. Describe the types, principles of operation and applications of special purpose clutches.
5. Describe the methods of actuating clutches.
6. Describe clutch selection, installation and maintenance procedures.
7. Describe the types and principles of operation of brakes.

C. Shafting, Fits and Accessories (160203c) ..... 4 Hours

Outcome: Describe shafts, fits and accessories.

1. Describe the types and applications of keys and splines.
2. Describe the types and applications of locking devices used with shafting.
3. Describe the types, uses, selection and characteristics of shafting.
4. Describe the system of fits for shafting and hubs.

D. Power Transmission: Belts (160203d) ..... 6 Hours

Outcome: Identify and describe installation and maintenance procedures for belt power transmissions systems.

1. Describe the types, construction and applications of V-belts.
2. Describe V-belt installation and maintenance procedures.
3. Describe the type, function and applications of synchronous belts.
4. Describe synchronous belt installation and maintenance procedures.
5. Describe the types, construction, application and maintenance of sheaves and pulleys.
6. Describe the types, construction and application of flat belts.
7. Describe flat belt installation maintenance procedures.

E. Power Transmission: Chain (160203e) ..... 6 Hours

Outcome: Identify and describe installation and maintenance procedures for chain power transmission systems.

1. Describe the type, construction and application of power transmission chains.
2. Describe power transmission chain standards and selection criteria.
3. Describe the installation and maintenance procedures for power transmission chains.
4. Describe the types and applications of chain sprockets.
5. Describe chain sprocket mounting, removal and maintenance procedures.

F. Gearing Fundamentals (160203f)..... 5 Hours

Outcome: Explain the fundamental terminology and characteristics of gears.

1. Explain gear terminology.
2. Describe the characteristics of various types of gears.
3. Describe the characteristics of various gear systems.

G. Gear Installation and Maintenance (160203g)..... 5 Hours

Outcome: Describe the installation, maintenance and overhaul procedures for gears and gearboxes.

1. Describe methods of checking the mesh patterns on mating gears.
2. Describe methods of setting and checking the backlash on mating gears.
3. Describe gearbox installation.

H. Variable Speed Power Transmission Devices (160203h)..... 2 Hours

Outcome: Describe the installation and maintenance procedures for variable speed power transmission devices

1. Describe the construction, application and maintenance of belt type, variable speed units.
2. Describe the construction, application and maintenance of chain type, variable speed units.
3. Describe construction, application and maintenance of hydraulic type, variable speed units

SECTION FOUR..... ALIGNMENT .....8 HOURS

A. Cross Dial Alignment (160204a)..... 8 Hours

Outcome: Align two machines using either the cross dial method or the reverse dial method.

1. Explain the relationship between rim dial readings and misalignment.
2. Determine the alignment corrections required to align two machine shafts in the vertical plane, using the cross dial graphical method.
3. Determine the alignment corrections required to align two machine shafts in the horizontal plane using the cross dial graphical method.
4. Calculate the alignment corrections required to align two machine shafts in the vertical plane, using the cross dial formulae method.
5. Calculate the alignment corrections required to align two shafts in the horizontal plane, using the cross dial formula method.

SECTION FIVE .....RECIPROCATING COMPRESSORS .....24 HOURS

A. Compressor Fundamentals (160205a)..... 4 Hours

Outcome: Describe the fundamentals of compressors.

1. Explain gas theory and gas law.
2. Describe compressor applications.
3. Describe compressor classification methods.
4. Identify reciprocating compressor components.
5. Explain the basic compressor system.
6. Describe basic compressor terminology.

B. Repair of Compressor Stationary Components (160205b)..... 4 Hours

Outcome: ***Explain installation and repair of compressor stationary components.***

1. Describe frame/crankcase and foundation inspection and repair methods.
2. Describe the types, inspection and repair of compressor bearings.
3. Describe the inspection and repair procedures for cylinders.

C. Repair of Compressor Moving Components (160205c)..... 4 Hours

Outcome: Explain reciprocating compressor component inspection and repair.

1. Describe the inspection and repair procedures for crankshafts.
2. Describe the types, inspection and repair of connecting rods.
3. Describe the installation, inspection and repair of crossheads.
4. Describe the function, inspection and reconditioning procedures of pistons and piston rods.

D. Repair of Compressor Valves and Gas Sealing (160205d)..... 4 Hours

Outcome: Describe reciprocating compressor valves and gas sealing inspection and repair.

1. Describe the types, inspection and repair of compressor valves.
2. Describe the types, inspection and repair of piston rod packing.

E. Compressor Servicing (160205e)..... 4 Hours

Outcome: Explain reciprocating compressor servicing.

1. Describe function and components of internal and frame lubrication systems.
2. Describe function and components of external frame lubrication systems.
3. Describe types of air filtration.
4. Describe types of compressor cooling systems.
5. Describe types of failure analysis techniques.

F. Compressor Overhaul and Start-up Procedures (160205f) ..... 4 Hours

Outcome: Explain reciprocating compressor overhaul and start-up procedures.

1. Explain the safety in regards to reciprocating compressors.
2. Explain the importance of manufacturer specifications and manuals.
3. Describe reciprocating compressor dismantling and reassembly procedures.
4. Describe compressor start-up procedures.

SECTION SIX .....CUTTING AND WELDING.....8 HOURS

A. Oxyacetylene Equipment and Procedures (160206a) ..... 5 Hours

Outcome: Describe the equipment and procedures used when performing heating, cutting and brazing operations.

1. Describe personal safety devices and procedures applicable to gas welding, cutting and heating operations.
2. Describe the properties and storage of gases used for welding purposes.
3. Describe oxyacetylene components and common routine maintenance procedures.
4. Describe general set-up procedures of oxyacetylene equipment.
5. Describe oxyacetylene welding procedures.
6. Describe oxyacetylene cutting procedures.
7. Describe propane heating procedures and the use of temperature indicators.

B. Electric Arc Welding (160206b)..... 3 Hours

Outcome: Describe the procedures and equipment used in electric arc welding operations.

1. Describe personal safety devices and procedures applicable to electric arc welding operations.
2. Describe types of electric arc welding machines.
3. Describe types and applications of electric arc welding electrodes.
4. Explain electric arc welding procedures.

SECTION SEVEN ..... LUBRICATION ..... 8 HOURS

A. Lubrication (160207a) ..... 8 Hours

Outcome: Describe the use of lubricants in industry.

1. Explain the characteristics of friction.
2. Describe the general characteristics of oil.
3. Explain lubrication theory.
4. Describe the types of oil and application of each type.
5. Describe the various oil lubrication systems and their applications.
6. Describe the properties and applications of the various types of greases.
7. Describe the various grease lubrication systems and their applications.
8. Describe the characteristics and application of dry solid lubricants.

SECTION EIGHT ..... TRADE MATH ..... 24 HOURS

A. Area, Volume and Capacities (160208a)

Outcome: Solve problems involving measurement and conversion using geometric formulas.

1. Identify key terms and concepts used in working with formulas.
2. Identify common formulas and solve problems for perimeter.
3. Identify common formulas and solve problems for area.
4. Identify common formulas and solve problems for volume.
5. Calculate the weight of a solid.
6. Calculate the capacity of a container in gallons.

B. Transmission of Force and Motion (160208b)

Outcome: Use formulas to solve trade-related problems involving the principles of the transmission of force and motion.

1. Identify key terms and concepts for working with formulas to calculate the mechanical advantage of simple machines.
2. Identify the three classes of levers and solve trade-related problems involving levers.
3. Solve trade-related problems involving the wheel and axle.
4. Solve trade-related problems involving inclined planes.
5. Solve trade-related problems involving screw jacks.
6. Solve trade-related problems involving pulleys.
7. Solve trade-related problems involving torque.
8. Solve trade-related problems involving pulleys and gears.

C. Gas Laws and Coefficient of Linear Expansion (160208c)

Outcome: Describe the gas laws and the effect of temperature on materials and perform calculations to solve problems relating to those laws.

1. Recognize the principles and applications of pressure and temperature as they relate to gas laws.
2. Solve trade-related problems involving the Perfect Gas Laws including Boyle's Law, Charles' Law, Gay-Lussac's Law and the Combined Gas Law.
3. Solve trade-related problems involving Pascal's Law.
4. Solve trade-related problems involving the coefficient of expansion of various ferrous, non-ferrous and synthetic materials.

D. Alignment Calculations (160208d)

Outcome: Use calculations for balancing a pair of dials, converting sweep readings into horizontal and vertical readings, accounting for sag and the formulas used during alignment.

1. Balance dial readings.
2. Convert sweep readings to horizontal and vertical readings and incorporate sag.
3. Use formulas to determine horizontal and vertical moves for aligning two shafts.

SECTION NINE.....APPLIED PRINT READING.....24 HOURS

A. Applied Print Reading: Auxiliary Views and Assembly Drawings (160209a)

Outcome: Sketch and interpret auxiliary views, sub assembly and assembly drawings.

1. Sketch and interpret a component in orthographic projection having an auxiliary view.
2. Define the purpose of assembly drawings.
3. Sketch the layout and features typical of sub-assembly drawings.
4. Sketch the layout and features typical of assembly drawings.
5. Interpret part identification methods and bills of material on assembly drawings.
6. Interpret information found on assembly drawings and sub-assembly drawings.

B. Applied Print Reading: Single Line Drawings (160209b)

Outcome: read and interpret and sketch single line drawings of piping systems.

1. Identify common piping symbols used on prints and working drawings.
2. Draw and label orthographic single-line pipe drawings and conversion to isometric drawings containing 90° elbows and tees.
3. Draw and label isometric single-line piping drawings containing 90° elbows and tees.

C. Castings (160209c)

Outcome: Read and interpret information found on a casting blueprint.

1. Describe the sand casting process.
2. Read and interpret casting drawings.

D. Basic Joints and Weld Types (160209d)

Outcome: Identify basic joints and welds.

1. Identify the five basic joints.
2. Describe the types of welds and their acceptable dimensions.
3. Identify joint and weld type variations.

E, Welding Symbols (160209e)

Outcome: Interpret welding symbols.

1. Explain the purpose of welding symbols.
2. Define weld symbol, welding symbol and supplementary symbols.
3. Draw and interpret basic weld symbols and welding symbols.
4. Identify the dimensioning of weld symbols.
5. Identify non-destructive testing symbols.

F. Applied Print Reading: Mechanical Components (160209f)

Outcome: read and interpret working drawings of gearboxes and compressors.

1. Demonstrate an ability to read and interpret drawings of gearboxes.

SECTION TEN ..... SHOP WORK ..... 72 HOURS

A. Gaskets
B. Bearings and Seal
C. Power Transmission
D. Alignment
E. Reciprocating Compressors
F. Cutting and Welding
G. Lubrication

THIRD PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE ..... HYDRAULIC AND PNEUMATICS .....44 HOURS

A. Introduction to Hydraulics (160301a) ..... 9 Hours

Outcome: Describe the fundamentals of power hydraulics.

1. Describe hydraulic system functions.
2. Draw and explain a simple hydraulic circuit.
3. Draw and interpret basic hydraulic circuits.
4. Explain the principles of hydraulic pressure and force.
5. Explain the principles of flow.
6. Explain hydraulic energy, work, power and efficiency.

B. Hydraulic Valves (160301b) ..... 5 Hours

Outcome: Describe the function, application and operation of hydraulic valves.

1. Explain the application, function and operating principles of pressure control valves.
2. Explain the application, function and operating principles of directional control valves.
3. Explain the application, function and operating principles of flow control valves.
4. Explain the application, function and operating principles of stack valves and cartridge valves.
5. Explain the application, function and operating principles of proportional and servo valves.

C. Hydraulic Pumps and Actuators (160301c)..... 6 Hours

Outcome: Explain the application, function and operating principles of hydraulic pumps and actuators.

1. List the types of hydraulic pumps and explain the operating principles, maintenance and applications of piston pumps.
2. Explain the operating principles, maintenance and applications of the various types of vane pumps.
3. Explain the application, function and operating principles of gear pumps.
4. Explain the application, function and operating principles of linear actuators.
5. Explain the application, function and operating principles of rotary actuators.

D. Accessories, Fluids and Seals (160301d) ..... 6 Hours

Outcome: Describe accessories, fluids and methods of sealing these fluids in hydraulic systems.

1. Describe the characteristics, applications and installation procedures for various seals used in hydraulic components.
2. Describe the methods used to specify particulate fluid contamination.
3. Describe the types, purpose, application and methods of specifying filters used in hydraulic systems.
4. Describe the types, purpose and application of accumulators.
5. Describe the types, purpose and application of reservoirs.
6. Describe the types and properties of hydraulic fluids.

E. Troubleshooting and Maintenance (160301e) ..... 6 Hours

Outcome: Describe maintenance and troubleshooting of hydraulic systems.

1. Describe open and closed loop circuits.
2. Describe maintenance and troubleshooting of conventional circuits
3. Describe basic troubleshooting of electro-hydraulic systems.

F. Pipe (160301f) ..... 4 Hours

Outcome: Describe fluid conductors and installation techniques.

1. Describe pipefitting and installation techniques.
2. Describe tube, tube fittings and installation techniques.
3. Describe flexible hose, fittings and installation techniques.
4. Describe soldering.

G. Valves (160301g) ..... 2 Hours

Outcome: Describe the construction, operation, maintenance and repair of various kinds of fluid control valves.

1. Describe valve types, construction, application and operation of valves.
2. Describe valve control methods and equipment.
3. Describe valve overhaul, maintenance and test procedures for valves.

H. Pneumatic Systems (160301h) ..... 6 Hours

Outcome: Explain pneumatic systems used in industrial applications.

1. Describe the safety procedures necessary when working with pneumatics.
2. Describe the basic pneumatic system.
3. Describe pneumatic systems, pneumatic valves, and schematics.
4. Describe pneumatic actuators.
5. Describe pneumatic maintenance procedures.

SECTION TWO ..... INDUSTRIAL REFRIGERATION AND HEAT EXCHANGERS ..... 14 HOURS

A. Industrial Refrigeration (160302a) ..... 6 Hours

Outcome: Describe the operation, basic maintenance and safety aspects related to industrial refrigeration systems.

1. List and explain the basic principles that apply to the vapour compression cycle and apply these to the operation of the cycle.
2. List and briefly explain the various components, refrigerants, oils and accessories of a vapour compression cycle.
3. Briefly explain the control of refrigeration systems.
4. Describe flooded systems and some common service and equipment maintenance.
5. Describe liquids overfeed systems and some common service and equipment maintenance.
6. Describe centrifugal systems and some common service and equipment maintenance.
7. Describe gas plant systems and some common service and equipment maintenance.
8. Describe absorption systems and some common service and equipment maintenance.

B. Heat Exchangers (160302b) ..... 6 Hours

Outcome: Describe the operation and maintenance of heat exchangers.

1. Describe the principles of heat exchange.
2. Describe types and construction of heat exchangers.
3. Explain troubleshooting, maintenance and repairs of heat exchangers.

C. Insulation (160302c) ..... 2 Hours

Outcome: Explain the use of insulation.

1. List and describe types of insulating materials.
2. List the hazards of some insulating materials and explain hazard prevention methods.
3. Describe the insulating values of various insulating materials.
4. Describe insulation application techniques.
5. Explain the purpose of lagging (cladding).

SECTION THREE ..... EXPLOSIVE AND AIR TOOLS ..... 5 HOURS

A. Air Tools (160303a) ..... 2 Hours

Outcome: Explain the use and care of air tools in industry. Explain control components as used in industry.

1. Describe safe operation of air tools.
2. Explain and describe the components and principles of air tools showing examples.
3. Describe the maintenance and storage of air tools.
4. Describe control components.

B. Explosive Actuated Tools (160303b) ..... 3 Hours

Outcome: Identify and describe explosive actuated tools, power loads and fasteners.

1. Differentiate between high and low velocity explosive actuated tools.
2. Describe explosive actuated tool power loads (low and high velocity), power load strength and safety requirements.
3. Describe explosive actuated tool fasteners, accessories and applications.
4. Assess base material suitability and related fastening requirements.
5. Describe explosive actuated system safety, firing procedure and tool maintenance.

SECTION FOUR ..... COMPRESSORS AND FANS ..... 26 HOURS

A. Screw Compressors and Lobe Blowers (160304a) ..... 8 Hours

Outcome: Describe the principles, components and maintenance of screw compressors and lobe blowers.

1. Describe types and operating principles of screw compressors.
2. Describe screw compressor components and accessories.
3. Understand the basic operation of common screw compressor capacity control systems.
4. Describe maintenance, troubleshooting and overhaul of screw compressors.
5. Describe types and operating principles of lobe blowers.
6. Describe lobe blower components and accessories.
7. Describe maintenance, troubleshooting and overhaul of lobe blowers.

B. Vane and Liquid Ring Compressors (160304b) ..... 8 Hours

Outcome: ***Describe principles, components and maintenance procedures for vane and liquid ring compressors.***

1. Describe types and operating principles of sliding vane compressors.
2. Describe sliding vane components and accessories.
3. Describe maintenance, troubleshooting and overhaul of sliding vane compressors.
4. Describe types and operating principles of liquid ring compressors.
5. Describe liquid ring compressor components and accessories.
6. Describe maintenance, troubleshooting and overhaul of liquid ring compressors.

C. Dynamic Compressors (160304c) ..... 7 Hours

Outcome: ***Describe principles, components and maintenance of centrifugal flow compressors and axial flow compressors.***

1. Describe types and operating principles of centrifugal flow compressors.
2. Describe centrifugal flow compressor components and accessories.
3. Describe types and operating principles of axial flow compressors.
4. Describe axial flow compressor components and accessories.
5. Describe maintenance, troubleshooting and overhaul of axial flow compressors.

D. Fans (160304d) ..... 3 Hours

Outcome: ***Describe principles, components and maintenance for fan components and accessories.***

1. Describe types and operating principles of fans.
2. Describe fan components and accessories.
3. Describe maintenance, troubleshooting and overhaul of fans.

SECTION FIVE .....DRYERS .....8 HOURS

A. Gas and Air Dryers (160305a) ..... 8 Hours

Outcome: ***Explain the use and care of air and gas dryers in industry.***

1. Explain safety of gas dryers.
2. Explain the principles of air and gas dryers.
3. Describe types of air and gas dryers.
4. Describe dryer maintenance and overhaul.

SECTION SIX ..... ALIGNMENT AND SURVEY ..... 14 HOURS

A. Laser Shaft Alignment (160306a) ..... 4 Hours

Outcome: Describe how to use laser equipment to align machine shafts and bores.

1. Review safety, rim and face and cross dial shaft alignment.
2. Explain the basic principles of laser equipment used for shaft alignment.
3. Describe the use of laser systems to align bores.

B. Optical Levelling and Alignment (160306b) ..... 6 Hours

Outcome: Describe optical levelling and alignment procedures.

1. Describe optical levelling and alignment instruments.
2. Describe optical levelling procedures.
3. Describe optical alignment procedures.
4. Describe tight wire alignment procedures.

C. Machine Levelling (160306c) ..... 4 Hours

Outcome: Describe how to install machinery at the correct location and elevation using laser equipment.

1. Review safety, grouting and levelling.
2. Describe types of laser levelling equipment.
3. Describe laser levelling applications and procedures.

SECTION SEVEN ..... COMPUTERS IN INDUSTRY ..... 17 HOURS

A. Information Gathering, Computers and Catalogues (160307a) ..... 8 Hours

Outcome: Use Internet, computers or catalogues to access critical equipment information.

1. Describe accessing critical equipment information using Internet, computers and catalogues.

B. Managed Maintenance Systems (160307b) ..... 9 Hours

Outcome: Describe computer maintenance management systems.

1. Use software applications for industrial maintenance and inventory records.
2. Use software applications for vibration analysis and predictive maintenance.
3. Use software applications for industrial process control.

SECTION EIGHT ..... NON-DESTRUCTIVE TESTING ..... 4 HOURS

A. Non-Destructive Testing (160308a) ..... 4 Hours

Outcome: Explain non-destructive testing.

1. Explain dye penetrate testing.
2. Explain magnetic particle testing.
3. Explain radiographic testing.
4. Explain ultrasonic testing.
5. Explain eddy current testing.

SECTION NINE ..... ELECTRICAL ..... 12 HOURS

A. Electrical Principles (160309a) ..... 6 Hours

The content of the electrical section in this course outline is not to suggest a journeyman millwright should complete tasks normally performed by a journeyman electricians. The intent is to provide the millwright with enough electrical knowledge so that safe decisions may be made when working on or around electrical equipment.

Outcome: Describe the basic principles of electricity and electromagnetism.

1. Describe the basic principles of electricity.
2. Explain the principles of magnetism and electromagnetism.
3. Describe the types of electric current, phases and cycles.
4. Explain the mathematical relationship between amps, volts, ohms and watts.

B. Practical Electricity (160309b) ..... 6 Hours

Outcome: Describe practical applications of electrical principles, identify safety problems, solve basic electrical problems and interpret basic electrical circuits.

1. Explain the safety procedures applicable when working on electrical equipment.
2. Identify potential electrical equipment hazards.
3. Describe the use of circuit breakers, disconnects, overload heaters and fuses.
4. Describe the principles and application of various electrical test meters.
5. Describe basic wiring systems.
6. Explain the purpose of electrical code.
7. Describe using test meters for testing circuits.
8. Describe electric motor replacement and maintenance procedures.

SECTION TEN ..... TRADE MATH ..... 16 HOURS

A. Hydraulic Calculations (160310a)

Outcome: Perform calculations involving areas of pistons, volumes of cylinders, describe the force/pressure/area relationship as it pertains to hydraulics, describe Pascal's Law and solve trade-related problems involving simple hydraulic systems.

1. Calculate areas of pistons, piston rod, annulus and volume of cylinders.
2. Describe Pascal's Law and describe how it applies to hydraulic systems.
3. Define force, pressure and area and describe the mechanical advantage of the force-area-pressure relationship.
4. Solve trade-related problems involving force-area-pressure, including intensifiers.
5. Solve problems involving hydraulic cylinder requirements including sizing of cylinders, cylinder speeds, and cylinder load capacities.
6. Solve trade-related problems involving relief valve settings in a hydraulic system.
7. Solve trade-related problems involving pump torque requirements in a hydraulic system.
8. Solve trade-related problems to determine flow rates of fluids in pipes, burst pressure and safe operating pressures of piping and forces required for operating hydraulic sheers and punches in hydraulic systems.

B. Electrical Calculations (160310b)

Outcome: Explain the mathematical relationship between amps, volts, ohms and watts.

1. Explain the mathematical relationship between amps, volts, and watts and solve trade-related problems involving current, electromotive force and resistance using Ohm's law and Kirchhoff's law.

SECTION ELEVEN ..... PRINT READING ..... 16 HOURS

A. Hydraulic and Pneumatic Systems (160311a)

Outcome: Interpret information contained on drawings of hydraulic and pneumatic circuits and component assembly drawings.

1. Read and interpret hydraulic circuits for the purpose of installation, troubleshooting and repair.
2. Read and interpret pneumatic circuits for the purpose of installation, troubleshooting and repair.

SECTION TWELVE ..... SHOP WORK ..... 64 HOURS

A. Hydraulics and Pneumatics

B. Industrial Refrigeration and Heat Exchangers

C. Explosive and Air Tools

D Compressors and Fans

E. Dryers

F. Alignment and Survey

G. Computer in Industry

H. Non-Destructive Testing

I. Electrical

FOURTH PERIOD TECHNICAL TRAINING
MILLWRIGHT TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS COURSE THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE ..... PRIME MOVERS .....49 HOURS

A. Stationary and Industrial Engine Fundamentals (160401a) ..... 3 Hours

Outcome: Explain the working fundamentals of industrial stationary engines.

1. Identify the major components of stationary industrial engines.
2. Explain engine operating principles.
3. Describe engine classifications methods.

B. Engine Component Identification and Repair (160401b) ..... 10 Hours

Outcome: ***Inspect and repair the major components of stationary industrial engines.***

1. Explain the appropriate safety procedures applicable to stationary industrial engines.
2. Describe disassembly and assembly procedures peculiar to stationary industrial engines.
3. Describe the function, construction, inspection and repair of engine blocks and cylinder liners.
4. Describe the function, construction, inspection and repair of the pistons, piston pins and piston rings.
5. Describe the function, construction, inspection and repair of connecting rods, crankshafts, flywheels and harmonic balancers.
6. Describe the function, construction, inspection and repair of camshafts, lifters and cam drives.
7. Describe the function, construction, inspection and replacement of engine bearings.
8. Describe the function, construction, inspection and repair of cylinder heads.

C. Engine Systems and Servicing (160401c) ..... 9 Hours

Outcome: ***Perform required servicing and preventive maintenance procedures on stationary industrial engines.***

1. Describe the lubrication systems, function, operation, inspection and service.
2. Describe the crankcase ventilation systems, function, operation, inspection and service.
3. Describe the cooling systems, function operation, inspection and service.
4. Describe the induction systems, function, operation, inspection and service.
5. Describe the ignition systems, function, operation, types, inspection and service.
6. Describe the fuels and fuel systems, function, types, operation, inspection and service.
7. Describe the starting systems, function, operation, types, inspection and service.
8. Outline methods used in basic tune-up, trouble-shooting and failure analysis.
9. State the purpose and methods of engine preventive maintenance programs.
10. List the functions of sensors used in industrial engines.

D. Engine Installation and Startup (160401d) ..... 2 Hours

Outcome: ***Describe the procedures for installing and starting stationary industrial engines.***

1. State correct engine installation procedures.
2. Explain engine start-up procedures and checks.

E. Steam Turbines (160401e) ..... 12 Hours

Outcome: ***Describe working principles, installation, start-up, maintenance and repair procedures for steam turbines.***

1. Explain the safety procedures applicable to steam turbines
2. Describe the types, applications, advantages and disadvantages of steam turbines.
3. Describe the working principles of steam turbines.
4. Describe the function, inspection and maintenance of small steam turbine components and systems.
5. Describe the function of large steam turbine components and systems.
6. Describe disassembly/reassembly, inspection, servicing and maintenance procedures for large steam turbines.
7. Describe installation and start-up procedures for steam turbines.
8. Describe equipment related to the operation of steam turbines.

F. Gas Turbines (160401f) ..... 6 Hours

Outcome: ***Describe working principles, installation, start-up, maintenance and repair procedures for gas turbines.***

1. Describe the applications, advantages and disadvantages of gas turbines.
2. Describe the working principles of gas turbines.
3. Describe the function of gas turbine systems and components.
4. Describe inspection, servicing and maintenance procedures for gas turbines.
5. Describe installation and start-up procedures for gas turbines.

G. Governors (160401g) ..... 7 Hours

Outcome: ***Describe the operating principles and maintenance procedures for the various types of governors used on industrial stationary engines and steam and gas turbines.***

1. Describe the application of governors with regards to industrial stationary engines, steam turbines and gas turbines.
2. Describe the operating principles of mechanical and mechanical-hydraulic governors.
3. Describe the operating principles of hydraulic governors.
4. Describe the operating principles of electro-hydraulic governors.
5. Describe the operating principles and adjusting procedures for overspeed trip mechanisms.
6. Describe diagnosis, maintenance and safety procedures for turbine and stationary engine governors.

SECTION TWO ..... VIBRATION ..... 20 HOURS

A. Vibration Analysis (160402a) ..... 8 Hours

Outcome: ***Explain causes of vibration and ways to detect what causes a machine to vibrate.***

1. Explain vibration using the associated terminology.
2. Describe methods of measuring vibration.
3. Describe how strobe lights are used to measure phase angles and check shaft rpm.
4. Describe machine signature and its importance in vibration analysis.
5. Explain the causes of vibration in rotating equipment.
6. Explain basic vibration analysis.
7. Explain the use of vibration analysis as a part of a predictive maintenance program.
8. Describe solutions to vibration problems.

B. Balancing (160402b)..... 4 Hours

Outcome: Explain balancing methods.

1. Describe causes of imbalance.
2. Describe the types of imbalance.
3. Define imbalance and balancing.
4. Explain imbalance correction methods and considerations.
5. Explain the single plane method of balancing.
6. Explain the two-plane vector method of balancing.

C. Electrical Controls and Troubleshooting (160402c)..... 4 Hours

The content of the Electrical section in this course outline is not to suggest a Journeyman Millwright should complete tasks normally performed by Journeyman Electricians. The intent is to provide the Millwright with enough electrical knowledge so that safe decisions may be made when working on or around electrical equipment.

Outcome: Explain industrial control principles.

1. Explain the safety procedures applicable to industrial controls.
2. Describe troubleshooting techniques.

D. Industrial Controls: Schematics, Ladder Diagrams and Logic Control (160402d) ..... 4 Hours

Outcome: Explain industrial control principles.

1. Interpret electrical ladder diagrams and understand electrical troubleshooting techniques.
2. Explain basic electrical control systems.
3. Describe air logic control operation.

SECTION THREE ..... MACHINE LEVELLING .....7 HOURS

A. Advance Alignment (160403a) ..... 7 Hours

Outcome: Align and then purposely misalign a multiple chain of cold, non-rotating machines to a very high degree of accuracy so that the machines are aligned when running and loaded.

1. Review safety, rim and face and cross dial shaft alignment.
2. Explain the various techniques used to measure machine thermal and process movement.
3. Demonstrate graphical solutions for solving multi-machine shaft alignment.

SECTION FOUR .....PUMPS.....16 HOURS

A. Dynamic Pump Selection (160404a) ..... 4 Hours

Outcome: Explain the working principles and selection procedures for dynamic pumps.

1. Explain dynamic pump principles.
2. Explain the procedure for selecting dynamic pumps.

B. Dynamic Pump Construction (160404b)..... 6 Hours

Outcome: Explain the construction of dynamic pumps.

1. Describe pump impeller styles.
2. Describe types and applications of dynamic pumps.
3. Describe pump and system components.

C. Positive Displacement Pumps (160404c) ..... 4 Hours

Outcome: Explain the construction, selection and operation of positive displacement pumps.

1. Explain positive displacements pump principles.
2. Describe types and applications of reciprocating pumps.
3. Describe types and applications of rotary positive displacement pumps.
4. Describe pump and system components.

D. Pump Operation and Repair (160404d) ..... 2 Hours

Outcome: Perform pump troubleshooting, maintenance and repair procedures.

1. List conditions that affect pump operations.
2. Describe pump maintenance and repair procedures.

SECTION FIVE .....MECHANICAL SEALS AND PACKING .....8 HOURS

A. Mechanical Seals (160405a) ..... 5 Hours

Outcome: Describe the principles, inspection and replacement procedures for mechanical seals.

1. Describe the working principles and components of mechanical seals.
2. Describe the various types of mechanical seals.
3. Describe the procedures for inspecting and replacing mechanical seals.

B. Compression Packing (160405b) ..... 3 Hours

Outcome: Describe the principles, inspection and replacement procedures for compression packing.

1. Describe the working principles and components of compression packing.
2. Describe the application of compression packing.
3. Describe the procedure for re-packing pumps and valves.

SECTION SIX ..... CONVEYOR SYSTEMS ..... 16 HOURS

A. Belt Conveyors (160406a) ..... 6 Hours

Outcome: Describe the application, operation and maintenance of belt conveying systems.

1. Describe general conveyor belt designs.
2. Describe belting construction, joining and repair methods.
3. Describe conveyor belt pulleys and drives.
4. Describe conveyor belt carrying and return idlers.
5. Describe maintenance and setup procedures for conveyor belts.

B. Chain, Bucket, and Screw Conveyors (160406b) ..... 5 Hours

Outcome: Describe the application, operation and maintenance of various conveyor systems.

1. Describe chain conveyor applications, construction, maintenance and repair.
2. Describe bucket elevator applications, construction, maintenance and repair.
3. Describe screw conveyor applications, construction, maintenance and repair.
4. Describe pneumatic conveyor applications, construction, maintenance and repair.
5. Describe vibrating and air slide conveyor application, construction, maintenance and repair.

C. Package Handling Roller Conveyors (160406c) ..... 5 Hours

Outcome: Describe the construction, maintenance and repair of package roller conveyors and their accessories.

1. Describe characteristics and construction of package handling roller conveyors.
2. Describe repair and maintenance procedures for roller conveyors.
3. Describe the accessories used with package handling roller conveyors.
4. Describe repair and maintenance procedures for roller conveyor accessories.

SECTION SEVEN ..... PLANNING AND SCHEDULING ..... 4 HOURS

A. Maintenance Planning (160407a) ..... 4 Hours

Outcome: Explain the planning of maintenance procedures for machine maximum uptime and safety.

1. Describe estimating procedures.
2. Explain purchasing procedures.
3. Explain maintenance scheduling and record keeping.

SECTION EIGHT ..... TRADE MATH ..... 16 HOURS

A. Dynamic Pump Calculations (160408a)

Outcome: Perform calculations and interpret graphs to dynamic pump selection.

1. Identify terminology and perform calculations relating to dynamic pump data.
2. Interpret pump graphs.

B. Advanced Trade Calculations (160408b)

Outcome: Solve advanced trade calculations using formulas, graphs and charts.

1. Perform calculations for advanced alignment problems using graphs and formulas.
2. Perform advanced hydraulic problems using formulas.
3. Perform calculations for advanced trigonometric problems.

SECTION NINE ..... PRINT READING ..... 24 HOURS

A. Reading, Interpretation and Cross Reference of Industrial Drawings

Outcome: Interpret and cross reference industrial drawings.

1. Installation and repair of:
   a) engines
   b) pumps
   c) conveyor systems
   d) elec. pneumatic schematics

SECTION TEN ..... WORKING AND COACHING SKILLS AND ADVISORY NETWORK ..... 0 HOURS

A. Workplace Coaching Skills ..... 0 Hours

1. Describe and demonstrate the coaching skills used for training apprentices.

B. Advisory Network ..... 0 Hours

1. Explain the role and purpose of the advisory network system in the Millwright trade.

SECTION ELEVEN ..... SHOP WORK ..... 80 HOURS

A. Prime Movers

B. Vibration

C. Machine Levelling

D. Pumps

E. Mechanical Seals and Packing

F. Conveyor Systems

G. Planning and Scheduling

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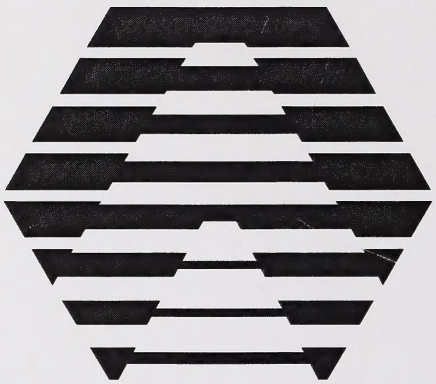

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